Establishing key estuaries and coastal waters for monitoring in the Cradle Coast NRM region

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Project description

This is an NRM funded project being run through Tasmanian Aquaculture and Fisheries Institute (University of Tasmania) in Hobart for a duration of approximately 12 months. This project is an extension of past and current work on environmental condition of estuaries conducted by the Estuarine Ecology group at TAFI. It builds on a similar project "Establishment of an Integrated Water Quality Monitoring Framework for Georges Bay". We hope to implement a similar process with estuaries and coastal waters in the Cradle Coast region, aiming to involve as many stakeholders as possible including councils, community groups, industries, state government and research institutes.

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Introduction

Estuaries are the transition zones between land and sea, and due to their comparatively small size they are often overlooked for monitoring relative to larger freshwater and marine ecosystems. However, these are highly productive ecosystems that often support a wide range of activities, from urban centres, to aquaculture and recreational activities.

The NRM Cradle Coast funded project on 'Developing Water Quality Objectives and Targets for Estuaries and Marine Waters' has the Objective to:

> *Develop a program that will establish water quality objectives and targets and a monitoring program for estuaries and coastal marine waters in north-western Tasmania.*

The purpose of monitoring estuaries and coastal waters is to assess their condition and to detect any changes in the general health of these systems over time. The information collected should be readily available to everyone and thus be of benefit to the whole community, in particular user groups of estuaries and coastal waters such as local councils, industry, and those involved in recreational activities of swimming, boating, fishing etc.

Because of limited resources available for monitoring, it is important to coordinate monitoring activities between the different user groups if we are to maximise the value and usefulness of the data collected. Thus monitoring programs which bring together results of monitoring by community groups such as Waterwatch, local council, industry such as Australian Paper, State government and NRM funded projects are likely to be the most beneficial to everyone in the region. This is going to require a major coordination exercise and collaboration between the different user groups but the outcome of a better understanding of the condition of estuaries and coastal waters which will underpin improved management is in the interests of everyone in the community.

This discussion paper targets the establishment of key estuaries and coastal waters for monitoring in the Cradle Coast region. Because funding and resources for monitoring are likely to be limited, estuaries and marine waters need to be prioritised according to their need/suitability for monitoring.

Unfortunately little information is currently available on the condition of estuaries and marine waters in the Cradle Coast region. Thus the first task will be to gather baseline condition information. A number of estuaries in the region are already obviously degraded and no data exist on their pristine condition, making it impossible to

quantify the changes that have already occurred. Thus today's condition has to be the benchmark for assessing change in the future. However, we can make comparisons between relatively undisturbed estuaries ('reference estuaries') and those that have been impacted as a means of estimating the current condition of an estuary.

Recommended indicators of the condition of estuaries and coastal waters are currently being developed (draft indicators for Tasmania are available at http://www.dpiw.tas.gov.au/inter.nsf/WebPages/LBUN-6N59JM?open and a report documenting recommended monitoring methods is currently being prepared and will be circulated by the end of June. These indicators are a subset of the national set of indicators developed by Scheltinga et al (2004) for the Department of Environment and Heritage. This 'Users' Guide to Estuarine, Coastal and Marine Indicators for Regional NRM Monitoring' is available from:www.coastal.crc.org.au/Publications/indicators.html.

Suggested key estuaries and coastal waters for monitoring and the process used to derive them are provided in this discussion paper. It is the intention of this paper to stimulate discussion and get comments; also to highlight any factual errors or information that has been missed. A workshop will be held in a couple of months to discuss the development of the monitoring framework, including which estuaries to monitor where and when, methods to be used, reporting, analysis and interpretation of data and developing collaborations between different groups involved in monitoring. It is hoped that stakeholders in the Cradle Coast region will use this workshop as an opportunity to express their thoughts regarding the selection of key estuaries and coastal waters, as well as provide constructive input into the establishment of a monitoring program.

Physical and environmental background of the Cradle Coast Region

The Cradle Coast Region encompasses an area that includes the north-west and west coasts of Tasmania. The area is bounded by 2640 km of coastline (CCNRM, 2005) and covers an area of approximately one third of the state. The bulk of the population lives along a strip on the north-west coast, with estuaries providing a foci for many population centres including Devonport, Burnie, Ulverstone, Wynyard, Smithton and Stanley (Figure 1).

The climate of the Cradle Coast is temperate maritime. There are quite large differences in average rainfall, with the majority of the west coast receiving around 1400 mm on average, compared to 800-1000 mm along the north-west coast (CCNRM, 2005). Air temperature is also variable across the region. On the coast, air temperature tends to be warm and mild in the summer, with Burnie's temperatures ranging from 12°C to 20°C on average. Winters around the coastline are also comparatively mild, although snow can fall in the higher country all year round.

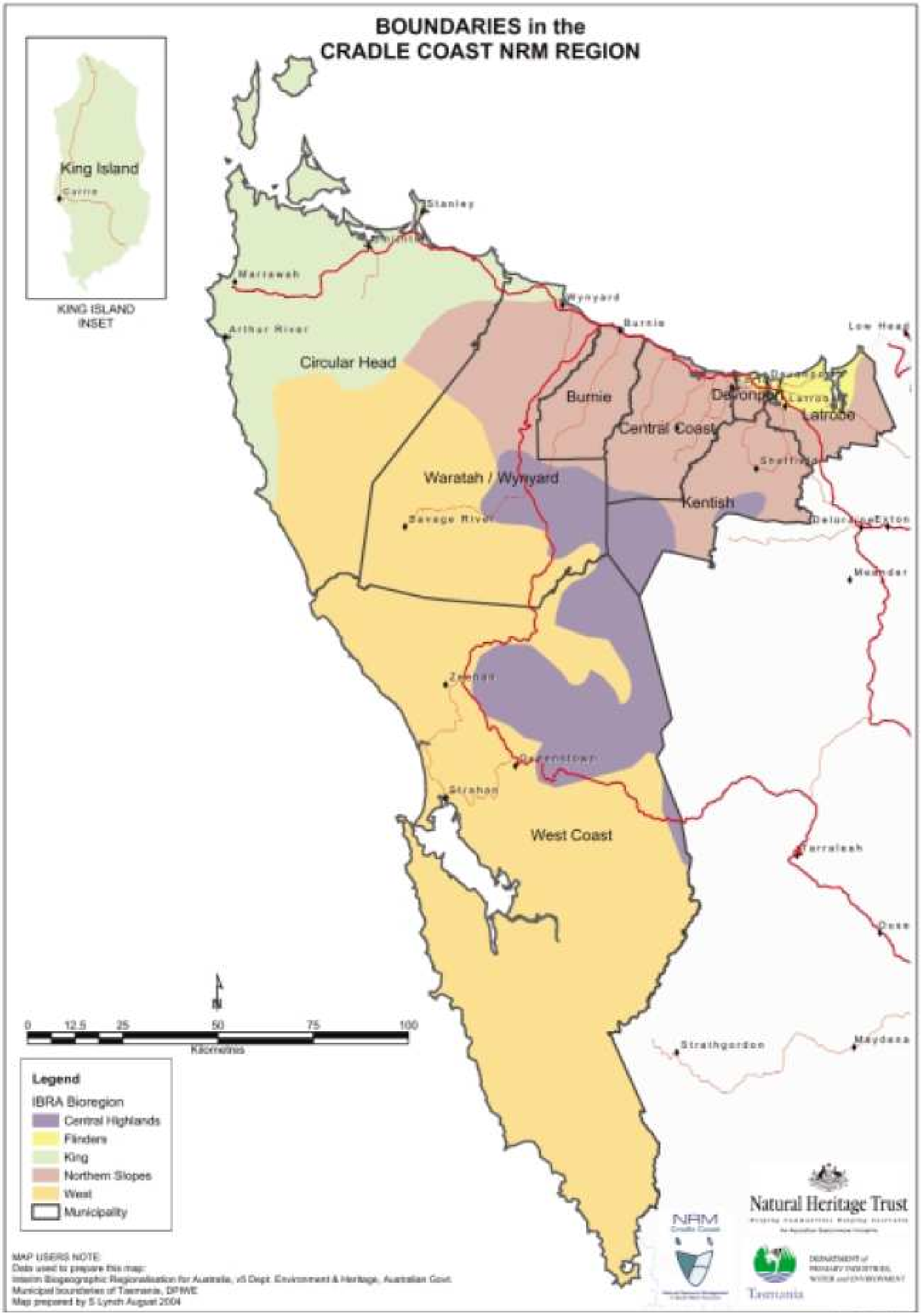

Figure 1. *Map of the Cradle Coast Region highlighting population centres, Municipalities, IBRA Bioregions and major estuaries*

Geologically, the Cradle Coast Region is diverse with rock types representing virtually every geological period (CCNRM, 2005). Tertiary basalt is a common

feature from Sassafras to Marrawah and is the basis of the fertile red ferrosol soils seen in the area. In the far north-west the dominant hill-forming rocks are very old, commonly of Cambrian or Precambrian age. Most of the flat landscapes of former swamplands and coastal margins are composed of sediments deposited over the last 2 million years. Small areas of acid sulphate soils are present in this area, particularly near the coast (G. Holz, pers. comm., 2006). Karst systems are also a feature of the Cradle Coast region, particularly in the far north-west and Gordon-Franklin catchment.

There are 20 major catchments plus many minor catchments in the Cradle Coast Region (Figure 2), which all vary depending on rainfall, topography and geology. West coast catchments originate in high, glaciated country and tend to have comparatively large catchments. For example, the Arthur and the Pieman both have catchments of 2500 km^2 and 4100 km^2 respectively. In terms of geomorphology, the Arthur is essentially undeveloped, whereas the Pieman has been modified to produce hydroelectricity. In contrast to the west coast, catchments flowing into Bass Strait are reasonably small. The Welcome, Montagu and Duck catchments of the far north-west are composed of branching channels that used to flow through extensive low-lying swamp forests. The Welcome and Montagu have been cleared and straightened into drainage channels to facilitate the expansion of farming (DPIWE, 2003b). The Cam, Emu, Blythe and Don Rivers all have steep, short catchments, with relatively intact riparian vegetation and farming activities primarily limited to nearby hilltops. The Mersey, Forth, Leven and Rubicon catchments are larger and cover some of the most fertile land in the state. The lower reaches of these catchments are extensively farmed, with cropping, grazing and dairy cattle prevalent. However, there are also large areas of National Park and State Forest in this part of the Cradle Coast Region, with the headwaters of the Mersey, Forth and Leven lying within World Heritage Area, and a part of the Rubicon catchment within the Narawntapu National Park.

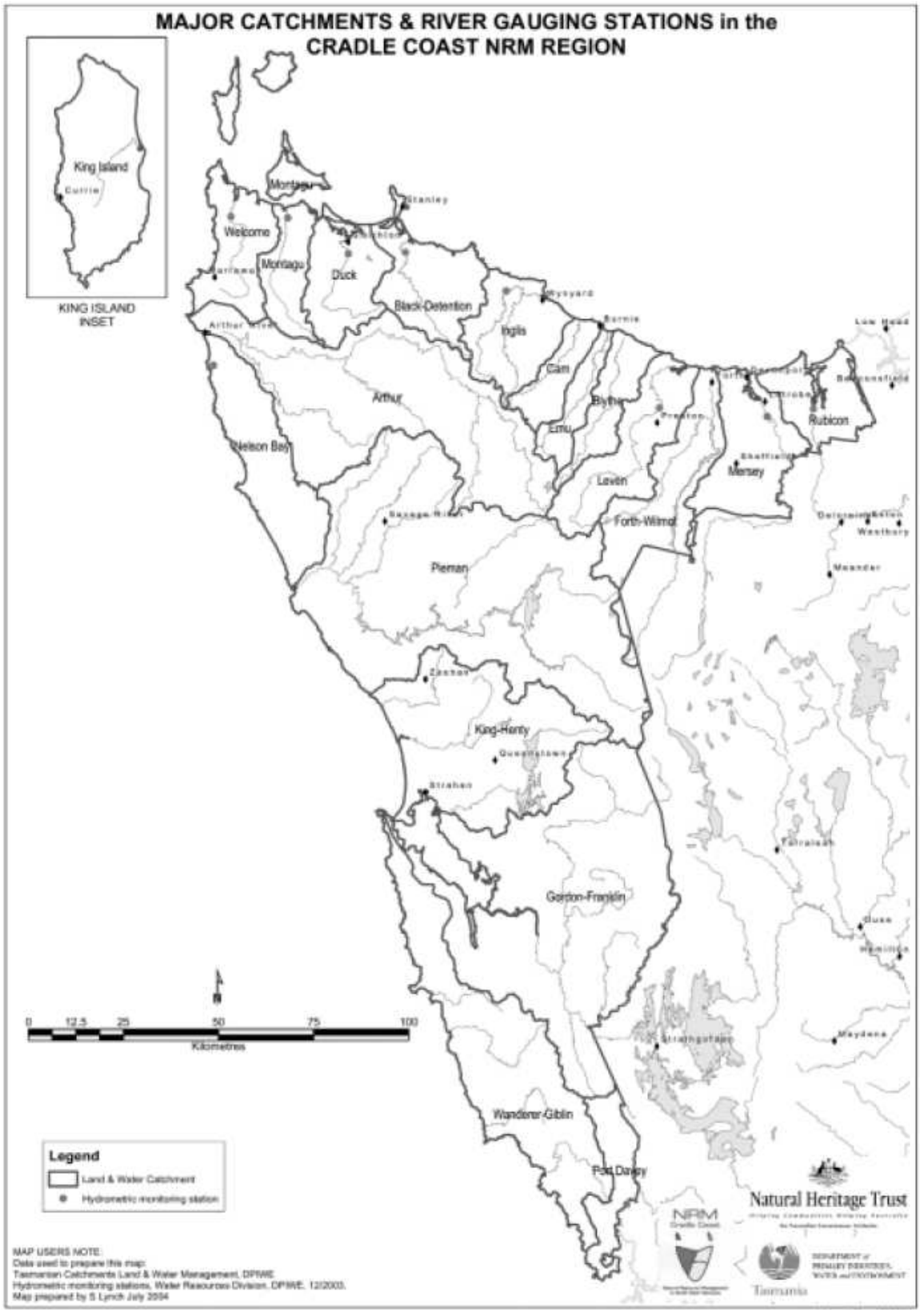

Figure 2. *Major catchments within the Cradle Coast Region*

The coastline included in the Cradle Coast Region is relatively diverse, with marine and estuarine environments including rocky reefs, wetlands, salt marshes, harbours and open coast (CCNRM, 2005). The Region includes the area from Port Sorell in the

north-west around to Payne Bay in the south-west, and features a total of 38 estuaries scattered around the coast. There are several areas within the Region that are recognised as significant habitats, including the Ramsar listed Lavinia State Reserve on King Island and the Robbins Passage-Boullanger Bay wetlands in the far north-west.

Estuaries within the Region vary on the basis of geomorphology. The size, shape, degree of tidal variation and incursion, and activities within the catchment strongly influence the environment and make each estuary unique (Edgar *et al*., 1999). The majority of estuaries in the Cradle Coast region are river estuaries. These are estuaries that develop where fast-flowing rivers discharge into the sea with little bar or lagoon development and poor water mixing. River estuaries on the north-west coast are classed as mesotidal due to the large tidal range of Bass Strait. In contrast, the river estuaries on the west coast have a much smaller tidal influence.

Table 1. *Geomorphic forms of major estuaries in the Cradle Coast Region (adapted from Edgar et al. (1999) and Hirst et al. (2005).*

Estuary	Geomorphic form
Port Sorell/Rubicon	Open marine inlet with strong freshwater influence
Mersey	Large mesotidal river estuary
Don	Large mesotidal river estuary
Forth	Large mesotidal river estuary
Leven	Large mesotidal river estuary
Blythe	Large mesotidal river estuary
Emu	Large mesotidal river estuary
Cam	Large mesotidal river estuary
Inglis-Flowerdale	Large mesotidal river estuary
Detention	Small mesotidal river estuary
Black	Large mesotidal river estuary
Duck	Tidal bay with strong freshwater influence
Montagu/Robbins Passage	Large mesotidal river estuary with freshwater influence extending into Robbins Passage
Welcome	Open marine inlet with strong freshwater influence
Arthur	Large microtidal river estuary
Pieman	Large microtidal river estuary
Macquarie Harbour	Drowned river valley
Wanderer	Barrier/Bar estuary

Several other forms of estuaries in the Cradle Coast Region are not quite as distinct. Port Sorell, Duck Bay and Welcome Inlet all have strong freshwater influences, but have openings that are more indicative of marine inlets (Port Sorell, Welcome Inlet) or bays (Duck Bay). Macquarie Harbour is unique in being the only drowned river valley in the Cradle Coast Region. It is an inherently complex system and has been the subject of many studies in the past. Due to this complexity and the difficulty of

implementing an appropriate monitoring program that could adequately assess the health of this system it was decided not to consider Macquarie Harbour further in this study. The Wanderer estuary is also distinct in being a seasonally barred river estuary, although due to its inaccessibility it was also not considered further in this study. Estuaries and coastal waters around King Island are being dealt with under a separate NRM proposal.

Importance of estuaries and coastal waters in the Cradle Coast Region

Estuaries and coastal waters are valuable environmentally, socially and economically to the Cradle Coast Region. Environmentally, estuaries in particular can be exceptionally productive systems and are essential in the life cycles of many marine and freshwater fish and invertebrates. Saltmarsh and seagrass, often found around estuaries in the Region, provide nutrients and habitat for marine biota and feeding grounds for birds. Coastal waters along Bass Strait have a high biodiversity, containing a greater number of species than any other coastal area in Tasmania.

The bulk of the human population in the Cradle Coast Region occurs on the coast, with most of the major towns and cities situated around an estuary. Coastal waters are enjoyed for recreation and provide significant lifestyle values. Many areas along the coast are viewed as “sea-change” areas, promoting a peaceful lifestyle that is close to nature. Health of waters in the Region is therefore important in the promotion of this lifestyle and ensuring that activities such as swimming, boating and recreational fishing can continue into the future.

Estuaries and coastal waters are also economically important for a number of reasons. Many tourists are attracted to the Region for the natural beauty of places like Rocky Cape National Park and the Arthur and Pieman River estuaries. Commercially, the Cradle Coast Region makes an important contribution to the wild fisheries resource in Tasmania. The blacklip abalone fishery operates up the west and far north-west coasts, whilst the greenlip abalone is harvested from the far north-west and King Island. The rock lobster fishery is also active throughout the Region, although catches are highest on the west coast. Finfish including garfish, flounder, warehou and flathead, as well as pale octopus are commercially fished within the Region. Several of these species, such as flounder, utilise estuaries in their life cycles. The aquaculture industry is also active in the Region, with Pacific oysters farmed at Port Sorell, Duck Bay and Robbins Passage.

Edgar *et al*. (1999) assessed the conservation significance of all estuaries in the Cradle Coast Region, rating them from Class A (critical conservation significance) to Class E (Low conservation significance – severely degraded). Very few of the major estuaries in the Cradle Coast rated well. Only the Black River estuary was rated as Class A and only the Arthur River estuary rated as Class B (high conservation significance). The Welcome, Montagu, Detention and Pieman were rated as Class C (moderate conservation significance), but all major estuaries from Port Sorell to the Inglis River estuary were classified as either degraded (Class D) or severely degraded (Class E).

Water quality objectives and ecosystem values

One of the final objectives of this project is to recommend water quality objectives and targets for estuaries in the Cradle Coast Region. These are a set of guidelines that must be met to maintain all the protected environmental values (PEVs) nominated for a specific body of water. PEVs have been established for most surface waters, including estuaries in the Region, and are outlined in Table 2 (DPIWE, 2000; DPIWE, 2003a). The PEVs are:

A. Protection of Aquatic Ecosystems
    (i) Pristine or nearly pristine ecosystems;
    (ii) Modified (not pristine) ecosystems:
    (a) from which edible fish, crustacea and shellfish are harvested, or
    (b) from which edible fish, crustacea and shellfish are not harvested.
B. Recreational Water Quality and Aesthetics
    (i) Primary contact water quality
    (ii) Secondary contact water quality
    (iii) Aesthetics water quality
C. Raw Water for Drinking Water Supply (generally not applicable to estuaries)
D. Agricultural Water Use (generally not applicable to estuaries)
E. Industrial Water Supply

Although important in the process of determining water quality objectives and targets, the PEVs for estuaries in the Cradle coast region are identical and thus of limited value in selecting key estuaries for monitoring.

Table 2. *PEVs for estuaries within the Cradle Coast Region from DPIWE 2000, DPIWE 2003a (see above for description of PEVs)*

Estuary	A	B	E
Port Sorell/Rubicon	YES – (ii) a	YES – (i) (ii) (iii)	YES – Intake for aquaculture in Marine Farming Zones
Mersey	YES – (ii) a	YES – (i) (ii) (iii)	
Central Coast estuaries (Don, Forth, Leven, Emu & Cam)	YES – (ii) a	YES – (i) (ii) (iii)	
Blythe	YES – (ii) a	YES – (i) (ii) (iii)	
Inglis-Flowerdale	YES – (ii) a	YES – (i) (ii) (iii)	
Black & Detention	YES – (ii) a	YES – (i) (ii) (iii)	
Duck	YES – (ii) a	YES – (i) (ii) (iii)	YES - Intake for fish processing at Stanley Wharf
Montagu	YES – (ii) a	YES – (i) (ii) (iii)	
Welcome	YES – (ii) a	YES – (i) (ii) (iii)	
Arthur	YES – (ii) a	YES – (i) (ii) (iii)	
Pieman	YES – (ii) a	YES – (i) (ii) (iii)	

Water quality objectives need to be developed in consultation with the Environment Branch of the Department for Tourism, Arts and the Environment (DTAE). They are set by the Board of Environmental Management and Pollution Control under the EMPC Act (1994) and generally require two years of monitoring before being established. Due to the short time frame, this may not be possible for the estuaries and coastal waters in the Cradle Coast Region that lack substantial existing data.

The State government has also been auditing Tasmania's freshwater ecosystem values through the Conservation of Freshwater Ecosystem Values (CFEV) project. This project is designed to assist in the assessment of future water development proposals and to assist in focusing management efforts to protect and/or restore high conservation values (DPIW, 2006a). Values are being assigned to a number of ecosystem types, including estuaries as freshwater dependent systems. The audit was conducted with the ecosystem variables classified and the condition (naturalness) assessed. The estuarine data used in this process was primarily derived from Edgar *et al*. (1999) and Murphy *et al*. (2003). The output of the audit is a database, where ecosystem types are attributed with their biological and physical classes, as well as a naturalness score. This process aids in the identification of estuaries of high conservation value. This database is still being developed, with a public interface to become available.

Identified water quality threats

Edgar *et al.* (1999) identified nine major indirect threats to Tasmanian estuaries: (i) increased siltation resulting from land clearance and urban and rural runoff, (ii) increased nutrient loads resulting from sewage and agricultural use of fertilisers, (iii) urban effluent, (iv) foreshore development and dredging, (v) marine farms, (vi) modification to water flow through dams and weirs, (vii) acidification of rivers and heavy metal pollution from mines, (viii) the spread of introduced pest species, and (ix) long term climate change.

The first eight of these impacts affect most estuaries in the Cradle Coast Region albeit at different scales. However, long term climate change has the potential to affect all estuarine ecosystems with sea level rise, changes to freshwater flow and increase in water temperature, amongst predicted effects.

Some estuaries in the Cradle Coast Region are amongst the most degraded in Tasmania (Edgar et al 1999). The major impacts on water quality include urbanisation, industry, clearing, cropping and grazing. Most estuaries are subject to multiple impacts (Table 3), some arising indirectly from the catchment, and others impacting directly upon the estuary.

In regard to effects arising from the catchment activities, agriculture is the main commercial land use in the Cradle Coast Region (CCNRM, 2005), with the far northwest being prime dairy and beef county, and the fertile central coast region supporting extensive cropping. Unfortunately, agriculture can impact on the water quality of estuaries, particularly where effects from the catchment are concentrated downstream, for example the high levels of *E.Coli* that have been recorded in the Robbins Passage area downstream of extensive dairy farming in the Montagu catchment (Tasmanian Shellfish Quality Assurance Program). Extensive land clearance can cause siltation of waterways leading to high turbidity and accumulation of sediment in estuaries. Runoff from fertilisers can increase nutrient loadings in catchments (DPIWE, 2003b), which may lead to eutrophication and the appearance of nuisance algal species. Pesticides and herbicides also have the potential to affect waterways, as do acid sulphate soils, which are emerging as an issue along the coast (G. Holz, pers. comm., 2006). In some parts of the Cradle Coast Region there is no buffer between farmland and estuarine zones, with cattle having direct access to the water.

Table 3. *Activities and issues within estuaries and catchments with the potential to effect water quality*

	Mining	Forestry	Hydroelectricity	Cropping	Dairy & other agriculture	Marine Farming	Other Industry	Stormwater and/ or sewage	Waste disposal sites	Acid sulphate soils	Water way modification	Conservation rating *	COMMENTS
Port Sorell		X		X	X	X	X	X	X		X	D	
Mersey		X	X	X	X		X	X			X	E	
Don				X	X			X			X	E	
Forth	X	X	X	X	X			X			X	D	
Leven		X		X	X		X	X	X			E	Only un-dammed catchment on NW coast
Blythe		X		X	X		X					D	
Emu		X		X	X		X	X			X	E	
Cam		X		X	X		X	X	X		X	E	
Inglis-Flowerdale		X		X	X			X			X	E	
Detention		X			X			X				C	
Black		X			X							A	Only Class A estuary in NW Tasmania
Duck		X			X	X	X	X	X	X	X	D	
Montagu/Robbins Passage		X			X	X				X	X	C	Robbins passage – significant wetlands
Welcome		X			X						X	C	
Arthur	X	X						X				B	
Pieman	X	X	X								X	C	

* From Edgar, G.J., Barrett, N.S. & Graddon, D.J. (1999) "A classification of Tasmanian estuaries and assessment of their conservation significance using ecological and physical attributes, population and land use". Technical Report Series No 2. Tasmanian Aquaculture & Fisheries Institute, University of Tasmania.

A substantial proportion of the land in the Cradle Coast is used in forestry activities. The impact of forestry on catchments is a contentious issue. Forestry activities may potentially impact water quality through the release of large volumes of sediment when plantations are harvested. There is also concern about potential contamination of waterways by forestry pesticides and herbicides, with these currently being monitored by DPIW. The forestry industry continues to expand in the Cradle Coast Region, with the area forested increasing from 9450 ha in 1999 to over 16,000 in 2003 (CCNRM, 2005). The majority of plantations are in the Waratah-Wynyard municipality, although there is some forested land in all catchments within the Cradle Coast Region.

Other impacts within catchments that can potentially affect estuaries and coastal waters include mining, hydro-electricity and physical alteration of waterways. Acid mine drainage from the Mt Bischoff mine has been known to occur, with flood events a danger to the Arthur River system due to the rapid influx of highly acidic water into the system (Green, 2001). Hydro-electricity has also affected estuarine water quality in the Cradle Coast Region, including the Forth, the Mersey and the Pieman, through extremely rapid changes in flow. Large freshwater influxes of this nature can be low in dissolved oxygen and temperature, thus impacting on estuarine biota. Similarly, modifying waterways in a way that can change environmental flows e.g. damming, can also affect estuarine health.

Urbanisation is one of the largest direct impacts on many estuaries in the Cradle Coast Region. Human population centres are often associated with issues of sewage and waste disposal, and often include some form of industrial waste. Stormwater and runoff may transport a large amount of pathogenic organisms, as well as litter, oils, heavy metals and other urban contaminants into estuaries, particularly during periods of heavy rain. The Mersey, Leven, Emu, Inglis and Duck River estuaries are all sites of major population centres. Port Sorell is one of the fastest growing urban areas in Tasmania, with issues such as land clearance, coastal erosion and stormwater management requiring future work to maintain water quality of the estuary (Bentley, 2002). There is also a number of smaller shack sites scattered along the coastline, with seepage from under-performing septic systems having the potential to cause periodic bursts of poor water quality.

Coastal industry that release effluent directly can also impact on water quality. For example, the paint pigment factory (Tioxide Australia) on the mouth of the Blythe released an iron-rich acid solution into the water until it was closed in 1996. This acid solution stained seabed and beaches rust red and had a significant impact on the algal and benthic invertebrate communities (SDAC 1996). Other examples of industrial

sites on coastal and estuarine waterways include in the Australian Paper Mill at Emu Bay and Simplot near Ulverstone, which discharges waste through the sewage treatment plant outfall (Green, 2001). McCains in Smithton also produce waste that is discharged through the town's sewage treatment plant into Duck Bay.

Invasive species can also impact on the ecosystem health of estuarine and coastal areas. There are several estuaries and coastal waters that are affected by rice grass (*Spartina anglica*) infestations, including the Circular Head region and Port Sorell. Rice grass can lead to the accumulation of sediment, changing geomorphology, flow regimes and sediment dynamics in the area (DPIWE, 2002). This can in turn impact invertebrates, fish and shore birds, and affect marine farming as well as recreation fishing and boating. A management plan has currently been implemented by DPIWE, aiming to eliminate rice grass in the Circular Head region and control its spread in Port Sorell (DPIWE, 2002).

Water quality data available

Unfortunately, long term water quality data collected for estuaries and coastal waters in the Cradle Coast Region are relatively scarce. The majority of good long-term water quality data in the Region has been collected only for freshwater, with little information on estuarine and marine waters. The remainder of this section summarises the major datasets and reports that have been collated for estuarine and coastal waters in the region.

Tasmanian Shellfish Quality Assurance Program (TSQAP) monitoring

TSQAP are responsible for monitoring water quality on shellfish leases across Tasmania in relation to shellfish being safe for human consumption. They are particularly interested in pathogenic micro-organisms, algal biotoxins and hazardous chemicals from agricultural and industrial sources in the water column (Turnbull and Brown, 2003). Areas leased for shellfish production in the Cradle Coast Region include Port Sorell, Duck Bay and parts of the Montagu River estuary and Robbins Passage. TSQAP have collected data on water temperature, salinity and faecal coliform regularly from all of these locations (Table 4).

Table 4. *Monitoring of estuaries with shellfish leases in the Cradle Coast by TSQAP*

Parameter	Port Sorell	Duck Bay	Montagu
Water temperature	Regularly, 1986 to present	Regularly, 1990 to present	Regularly, 1998 to present
Salinity	Regularly, 1986 to present	Regularly, 1990 to present	Regularly, 1998 to present
Faecal coliform	Regularly, 1986 to present	Regularly, 1990 to present	Regularly, 1998 to present
Algal biotoxins	Once-off 2001, > 4 samples annually 2003 to present	Monthly 2001 to present, but not 2002	Data from Robbins Passage or Duck Bay inferred
Metal & chemical residues	Once in 1999, 2002, 2005	Once in 2002, 2005	Once in 2002, 2005

Bacterial levels within estuaries are often influenced by freshwater loading, with high flows resulting in increased numbers of faecal coliform in the growing area. Due to the direct relationship between the mixing of freshwater with saltwater and salinity levels, TSQAP have developed a correlation between salinity and faecal coliform in the water. On most “approved conditional” leases, closure from harvest occurs if the salinity levels drop below a certain predetermined point. This closure point can vary depending on the location of the lease within the estuary, but also tends to vary

between estuaries (Table 5). Closure levels are based on data collected over several years.

Table 5. *A summary of the open salinities or flows for Port Sorell, Duck Bay estuary leases, and the number of closures that occurred in 2004*

Estuary	Open salinity/ river flow	Total number days closed 2004
Port Sorell - Eastern arm	>23 ppt	155
- Western arm	>29 ppt	
Duck Bay	>32.5 ppt	88
Montagu/ Robbins Passage	Closure at 1 cumec	95

Biodiversity and degradation of estuaries in north-western Tasmania (Hirst et al., 2005)

Hirst *et al*. (2005) collected water quality and biological data from four estuaries on the north-west coast, the Black, Detention, Duck and Montagu. The aims of this study were to document baseline environmental data, assess current condition of these estuaries, investigate biological indicators of estuarine health and assess draft indicator levels for water quality. Parameters measured included salinity, dissolved oxygen, turbidity, dissolved nutrients (including ammonia, nitrate, nitrite and reactive phosphorus), sediment particle size and organic content, benthic macroinvertebrates and fish biodiversity. Nutrient levels for the Black, Detention and Montagu estuaries were within the Australian and New Zealand Environment and Conservation Council (ANZECC) water quality guidelines, although concentrations recorded from the Duck greatly exceeded them. However the benthic invertebrate data indicated that the upper reaches of both the Duck and Montagu were organically enriched, particularly when compared to the upper reaches of the Black estuary. This indicated that assessment based entirely on water quality measurements would underestimate the impact within the Montagu estuary (Hirst *et al*., 2005). This project is ongoing.

Estuarine health in Tasmania, status and indicators: Water quality (Murphy et al., 2003)

The Murphy *et al*. (2003) report provides a summary and assessment of water quality parameters from 22 estuaries around Tasmania, including the Arthur, Pieman, Black, Don, Mersey, Port Sorell and Duck Bay. Parameters were sampled at two monthly intervals and included temperature, salinity, dissolved oxygen, turbidity, nutrients (including NO_x-N, PO_4-P and SiO_4-Si), chlorophyll *a* and suspended solids. For key

water parameters, the baseline data were used to derive regional specific draft indicator levels (Table 6; Murphy *et al.*, 2003).

Table 6. *Draft indicator levels for estuarine water quality parameters (Murphy et al., 2005)*

Draft indicator levels		**Low**	**Medium**	**High**	**Very High**
Turbidity	NTU	0 to 4	4.1 to 10	10.1 to 20	>20
Chlorophyll *a*	µ g/L	0 to 2	2.1 to 5	5.1 to 10	>10
NO_x	µ g/L	0 to 20	21 to 50	51 to 100	>100
PO_4	µ g/L	0 to 5	6 to 15	16 to 30	>30

The data collected were then assessed in terms of these indicator levels, with many estuaries on the north coast recording high to very high readings for some parameters. Duck Bay and the Don estuary consistently had particularly high readings (Table 7).

Table 7. *Average turbidity (NTU), chlorophyll a, NOx and PO4 concentrations (µg l-1) and yearly median value for each estuary, July 1999 to June 2000 (from Murphy et al., 2003)*

		Sample						
Estuary	**Parameter**	**JA99**	**SO99**	**ND99**	**JF00**	**MA00**	**MJ00**	**Median**
Duck Bay	Turbidity	21.0	17.6	7.0	8.7	6.0	12.2	8.3
	Chlorophyll a	2.9	2.0	1.4	1.4	1.5	1.7	1.5
	NO_x	286	268	165	39	93	235	127
	PO_4	104	30	27	30	17	15	28
Black	Turbidity	8.9	3.9	3.8	3.0	2.9	3.1	3.4
	Chlorophyll a	0.2	0.1	0.8	0.9	0.7	0.2	0.4
	NO_x	95	62	48	24	48	55	57
	PO_4	5	6	3	9	5	1	4
Don	Turbidity	50.0	9.8	125.3	no data	8.1	4.5	8.6
	Chlorophyll a	2.5	0.7	25.6	17.6	0.7	0.1	0.8
	NO_x	1125	328	20	5	31	343	118
	PO_4	8	4	31	11	13	8	9
Mersey	Turbidity	12.0	3.6	13.3	no data	6.3	3.1	5.5
	Chlorophyll a	0.8	0.3	3.1	0.9	0.7	0.2	0.5
	NO_x	289	65	19	24	22	61	31
	PO_4	8	8	9	15	13	10	11
Port Sorell	Turbidity	39.9	6.6	5.4	no data	4.8	3.1	5.4
	Chlorophyll a	1.3	1.2	1.6	0.9	0.5	0.3	0.8
	NO_x	217	5	0	2	4	11	4
	PO_4	12	22	9	8	9	6	8
Pieman	Turbidity	2.9	9.8	1.8	1.6	4.6	2.6	2.6
	Chlorophyll a	0.0	0.0	0.0	0.1	0.2	0.0	0.0
	NO_x	28	22	36	20	21	19	23
	PO_4	1	0	0	2	0	0	0
Arthur	Turbidity	10.5	5.2	8.2	2.5	2.9	4.3	4.5
	Chlorophyll a	0.0	0.1	0.0	0.6	0.1	0.0	0.0
	NO_x	39	17	10	5	9	20	13
	PO_4	3	1	1	2	0	1	1

A classification of Tasmanian estuaries and assessment of their conservation significance using ecological and physical attributes, population and land use (Edgar et al., 1999).

As part of this study, Edgar *et al.* (1999) collected data on benthic macroinvertebrate fauna and physiochemical parameters (including temperature, turbidity, dissolved oxygen and salinity) on numerous estuaries in the Cradle Coast Region (Table 8). This data was incorporated into a much large dataset that includes land and population information as well as previously existing biological and physical data, and was used to establish conservation significance of estuaries in the Cradle Coast (see Table 3). There were several broad trends noted. Biomass and productivity was much lower on the west coast compared to the north-west, but abundances (total number of animals collected) in the Arthur and Pieman were only slightly lower than the north-west. The number of species recorded from sites on the west coast was also consistently quite low. Species richness on the north-west coast was more variable, with Welcome Inlet in the far north-west recording the highest number of species collected at one individual site in the Cradle Coast Region.

Table 8. *Physiochemical and macroinvertebrate data collected by Edgar et al. (1999)*

Parameters	Port Sorell	Mersey	Don	Forth	Leven	Blythe	Emu	Cam	Inglis	Detention	Black	Duck	Montagu	Welcome	Arthur	Pieman
Physio-chemical	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X
Macro invertebrates			X		X	X		X		X	X			X	X	X

Local Council Water Quality Data

Recreational water bodies are sampled by councils to ensure that the waters are safe for their respective uses (Central Coast Council, 2005). Councils tend to vary in regard to the exact specifics of their monitoring programs, although all councils in the Region, at minimum, monitor for coliform levels over the main bathing season, usually at a number of sites (Figure 3).

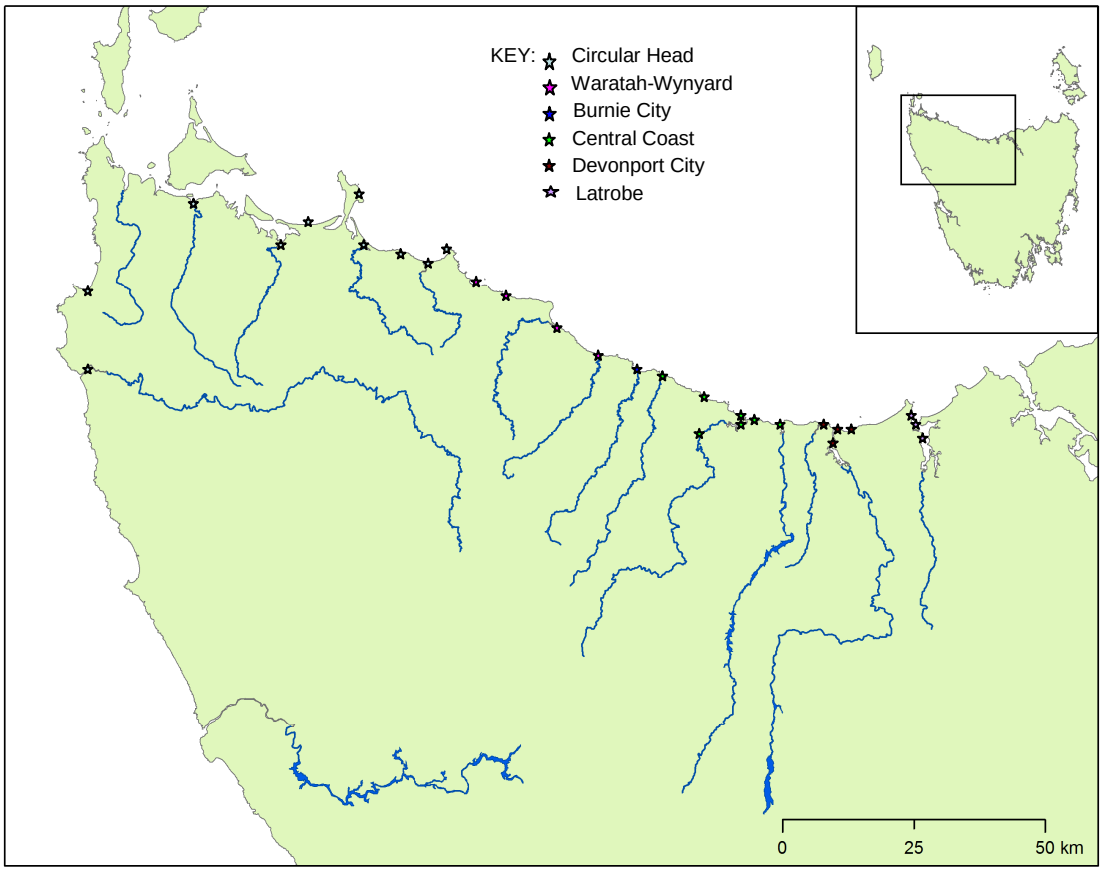

Figure 3. *Council recreational water quality monitoring sites within the Cradle Coast Region (due to scale of map, not all monitoring sites shown).*

State of surface waters report – Cradle Coast Region (North West Waterwatch, 2006; final draft)

The report presents the most recently available results of several organisations that monitor water quality in freshwater in the Cradle Coast Region. These organisations include North West Waterwatch, DPIW, Cradle Coast Water, Hydro Tasmania and the Kentish Council. The North West Waterwatch monitoring program has sites in all major catchments in the region, except in the extreme south-west. They monitor for a variety of parameters including turbidity, temperature, dissolved oxygen, pH, conductivity, nitrate-nitrogen, total phosphorus and benthic invertebrates. Results from 2004/05 indicated that elevated total phosphorus and nitrate levels were common in catchments in the Cradle Coast Region, whilst high turbidity was regularly recorded in the Mersey, Montagu and Rubicon catchments.

Waterways monitoring reports (DPIW 2006b)

DPIW conduct an extensive freshwater monitoring program in the Cradle Coast Region, which focuses on water quality. Each year DPIW release a report that summarises key data collected for each catchment in the form of a Waterways

Monitoring report. All major catchments within the Cradle Coast Region are monitored except the Detention and Don. The parameters that are monitored tend to vary from catchment to catchment but generally include Ausrivas assessments, temperature, conductivity, dissolved oxygen, turbidity, pH and nutrients (NO_x, ammonia, phosphates, total nitrogen and total phosphorus). Several catchments, including the Rubicon, Mersey, Leven, Inglis-Flowerdale, Duck and Montagu also have an automatic sensor stations located in stream, continuously collecting data on water temperature, conductivity, dissolved oxygen and turbidity.

Pesticide and herbicide monitoring (DPIW)

This program monitors Tasmanian water catchments for a variety of pesticides and herbicides, including sites in the Cradle Coast. The chemicals monitored include those commonly used in agriculture and forestry, as well as those with high toxicity or potential mobility in the environment. Catchments monitored for pesticides and herbicides in the Cradle Coast Region include the Welcome, Montagu, Duck, Inglis-Flowerdale, Cam, Leven, Mersey and Rubicon. Catchments have been monitored since 2005 and are sampled quarterly. There is also a flood monitoring program that measures pesticide and herbicide levels during flood events in the Duck catchment. Automatic sampling equipment is installed to collect samples during periods of significant water rise. As of the sampling run in January 2006, the only catchment to have returned a reading in access of the detection limits was the Rubicon for the chemical atrazine.

Key estuaries and coastal waters for monitoring

Key estuaries and coastal waters for monitoring need to be identified in the Cradle Coast because there are insufficient funds and resources to monitor all estuaries in the region. Unfortunately, the logistical and financial restraints on this project to establish a monitoring framework and initiate monitoring make it impossible to collect detailed baseline information and co-ordinate a monitoring program of all estuaries. It is estimated that this current project has funds and time to comprehensively assess and establish a monitoring program for approximately six estuaries in the Cradle Coast region.

Criteria used to identify key estuaries and coastal waters include:-

- Estuaries/coastal waters that are representative of the Region in a biophysical sense
- Levels of monitoring already conducted and likely to continue
- Levels of human activity/impact
- Groups reliant upon estuaries/coastal waters (e.g. marine farmers/industry/tourism)
- Areas of international or special significance (e.g. wetlands)
- Sensitive habitats/threatened species

In addition to these criteria, it is preferable that the estuaries are spread geographically throughout the Cradle Coast region so that representative geographical areas and communities are included. It is also crucial that estuaries and coastal waters selected for monitoring have key groups that can form linkages within an integrated monitoring program.

The six criteria are quite broad and may be conflicting, reflecting the wide range of issues and potential uses of estuaries and coastal waters in the Cradle Coast Region.

Ranking of estuaries

A preliminary ranking of estuaries based on how well they fit each criterion has been conducted, with these rankings added together to form an evaluation in terms of overall significance for monitoring. This proposed methodology gives each criterion equal weighting; however other methodologies may need to be considered, in particular the criteria may need to be ranked, if the key estuaries and coastal waters for monitoring to do meet general stakeholder expectations. Rankings are on sliding

scale, with a score of five suggesting a very good fit to the criterion and a score of zero indicating very little relevance.

Criterion 1 – Estuaries that are representative of the Region

This is possibly the broadest of the criteria for selecting key estuaries and/or coastal waters. In terms of geomorphology, river estuaries are by far the most common and therefore the representative estuary "type" of the Cradle Coast Region. With regard to physio-chemical properties, the estuaries on the west coast are different to those on the north-west. The Pieman and the Arthur exhibit dark tannin stained waters, higher flows and strong stratification that regularly lead to anoxia of the bottom waters (Murphy *et al*., 2003). In contrast, the estuaries of the north-west coast are dominated by the tidal movements and regular flushing. Port Sorell, Welcome Inlet, Duck Bay and the Montagu/Robbins Passage estuaries are also distinct in their geomorphic form within the Cradle Coast region by having extensive sand/mud flats in the lower estuary.

The Leven, Blythe, Cam, Inglis, Black, Arthur River, Port Sorell and Duck Bay estuaries all received the highest ranking for this criterion. The Leven, Blythe, Cam, Inglis and Black are large mesotidal river estuaries indicative of the north-west coast, the Arthur is a large microtidal estuary representative of the west coast, and Port Sorell and Duck Bay estuaries are representative of estuaries with extensive sand/mudflats All of the above estuaries have catchments of a reasonable size that lack substantial modifications (i.e. hydro activities or modifications for drainage). Although most catchments are modified by instream storage units of some description (as is common in the Cradle Coast Region), the hydrological connectivity of the main river channel generally remains intact. The above estuaries cover a spectrum of relatively modified estuaries (e.g. Blythe) to comparatively pristine estuaries (e.g. Black), which is characteristic of the Region. *Ranking 5*

The Don and Detention estuaries were not included in the above ranking based on the smaller size of their catchments, however their estuary type is representative of the region. The Welcome and Montague estuaries were also not included in the above ranking because of the major alterations to river flow, primarily drainage and rerouting for agriculture (DPIWE, 2003b; DPIWE 2005). *Ranking 3*

The Mersey, Forth, Emu and Pieman all rank together. Although they are all river estuaries – the "representative" estuary type in the Region – their freshwater flows into estuaries are all altered. The Mersey, Forth and Pieman all have hydro-electric activities in their catchments, whereas the Emu has a weir at the bottom of the

catchment interrupting the connectivity of freshwater flow. The impact of change in freshwater flows is not consistent between estuaries, and therefore none of these estuaries can be considered highly representative of altered river estuaries in the region. *Ranking 1*

Criterion 2 – Levels of monitoring already conducted

For this criterion, studies outlined in the previous section on water quality data available have been categorised according to the range of variables measured, the length of time that they've been running for and whether or not they collect estuarine data. These studies are outlined below in Table 9. This table is not all inclusive – only the major studies and monitoring programs are included.

Table 9. *Levels of monitoring conducted in estuaries in the Cradle Coast Region*
Note: Shaded cells indicate data collected for catchment only (not for estuary)

	Hirst *et al.* 2005	Murphy *et al.* 2003	TSQAP	Edgar *et al.* 1999*	Rec WQ monitoring	Outfall monitoring	Other estuarine monitoring**	Continuous monitoring station	Waterways reports	Waterwatch sampling	Cradle Coast Water	Pesticide/ herbicide monitoring	*RANKING*
Port Sorell		X	X	X	X	X		X	X	X		X	*5*
Mersey		X		X	X	X	X	X	X	X		X	*3*
Don		X		X*						X			*1*
Forth				X	X				X	X	X		*1*
Leven				X*	X	X		X	X	X	X	X	*3*
Blythe				X*	X		X		X	X			*1*
Emu				X	X		X		X	X			*2*
Cam				X*	X				X	X	X	X	*2*
Inglis				X	X			X	X	X		X	*2*
Detention	X			X*	X					X			*4*
Black	X	X		X*	X				X	X			*5*
Duck	X		X	X	X	X		X	X	X		X	*5*
Montagu	X		X		X			X	X	X		X	*5*
Welcome				X*					X	X		X	*1*
Arthur		X		X*	X				X	X			*4*
Pieman		X		X*					X	X			*1*

* Indicates sampling for macroinvertebrates occurred

** Includes data collected by ports and other industry, as well as council monitoring for stormwater.

The study by Hirst *et al*. (2005) is possibly the most comprehensive short term study to be conducted in Cradle Coast estuaries. Murphy *et al.* (2003) also provide good

baseline data on estuaries over a range of physiochemical parameters. TSQAP, whilst only collecting data for temperature, salinity and coliform, is a long running monitoring program and therefore is also categorised highly. Port Sorell, Duck Bay, the Black and the Montagu received the highest ranking for this criterion as these estuaries were study sites for two or more of these studies (Table 9). *Ranking 5*

Other major estuarine studies/sampling programs include local council recreational water quality sampling and sewerage outfall monitoring, as well as the study by Edgar *et al*. (1999). The estuaries that Edgar *et al.* (1999) sampled for macroinvertebrates receive a higher ranking than those where only physiochemical variables were sampled. Hence, the Arthur and Detention estuaries receive a high ranking for this criterion. These estuaries are both sites for council monitoring and have been monitored for invertebrates by Edgar *et al.* (1999). The Detention was also a study site for Hirst *et al*. (2005) and the Arthur a study site for Murphy *et al.* (2003). *Ranking 4*

Other estuaries that have been subject to large amounts of monitoring include the Mersey and the Leven. The Mersey has been subject to relatively comprehensive estuarine surveys, largely due to its status as a large port. Outfall monitoring done on the Leven estuary is quite comprehensive, with baselines provided for the estuary. A continuous monitoring station is present in the catchment, providing detailed data of freshwater flows entering the estuary. *Ranking 3*

Organisations such as DPIW, Waterwatch, Cradle Coast Water Authority, Hydro and Forestry all conduct water quality sampling in catchments. Although sampling rarely includes estuaries, data are still important as freshwater flows into an estuary often have substantial effects on water quality. Monitoring programs in catchments that include continuous monitoring stations ranked higher than once-off or spot sampling. The Emu, Cam and Inglis are included in this ranking due to the moderate amount of sampling in the estuary and larger amounts of sampling in the catchment. Like the Leven, the Inglis also has a continuous monitoring station in the catchment, whilst drinking water is drawn from the Cam, ensuring that there is regular monitoring conducted in the catchment. The Emu is included in this ranking due to the comprehensive stormwater monitoring program conducted by council. *Ranking 2*

From the information we have all other estuaries (Don, Forth, Blythe, Welcome and Pieman) have a moderate to small amount of work conducted in the estuary and catchment. *Ranking 1*

Criterion 3 – Levels of human activity

Estuaries in the region were separated into three categories – highly modified, comparatively unmodified and moderate change based on the activities in the catchment and the size of any townships sited on the estuary (Table 10). Levels of human activity in the catchment were determined from land use data (Table 11).

Table 10. *Size of major townships sited on estuaries in the Cradle Coast Region (data from Australian Bureau Statistics census 2001).*

Township	Population	Estuaries
Devonport	21,575	Mersey, Don
Burnie-Somerset	18,095	Emu, Cam
Ulverstone	9,515	Leven
Wynyard	4,635	Inglis
Smithton	3,149	Duck
Port Sorell	1,937	Port Sorell
Turners Beach	1,259	Forth
Heybridge	324	Blythe

Table 11. *Land use by percentage in each catchment of the Cradle Coast Region (from CCNRM, 2005) Note: The Don catchment is included in the Mersey and the Black and Detention are treated as one catchment. Data are approximate only.*

	Conservation	Other protected area	Production forestry	Plantation	Agriculture	Irrigated agriculture	Built environment	Minimal use	Water	Total catchment area (ha)
Rubicon	19	3	15	13	26	10	2	12	1	45 300
Mersey	6	8	10	16	36	7	5	13	1	72 300
Leven	12	3	23	28	22	6	2	3	0	73 000
Forth	30	7	20	10	21	5	1	4	2	81 500
Blythe	12	3	25	14	34	8	2	2	1	37 500
Emu	9	0	17	45	17	6	3	3	1	25 400
Cam	2		10	50	25	7	5	2	0	29 000
Inglis	8	1	16	25	37	7	2	5	0	61 300
Black-Detention	15	7	40	6	21	4	1	7	0	64 400
Duck	7	1	18	7	58	1	1	7	0	55 200
Montagu	13		27	6	15	14		25	0	47 400
Welcome	24	3	21	5	23	8		16		67 400
Arthur	25	9	50	13	2			1	0	251000
Pieman	32	35	24	2	1		1	3	2	414200

Any catchment that had a combined total over 60% of land dedicated to plantation forestry, agriculture, irrigated agriculture or built environment or a population number around the estuary greater than 2,000 was categorised as highly modified (Table 10). Any catchment that had over 20% of the land dedicated to conservation or some other form of protected area and negligible populations surrounding the estuary were classed as comparatively unmodified. All other estuaries were classified as having moderate change.

The estuaries were ranked 5 for highly modified, 3 for moderate change and 1 for comparatively unmodified (Table 12). This ranking assumes that highly modified estuaries are the most likely to respond to improved land management practices in the catchment. Ongoing monitoring of these estuaries should show improved condition where better management is implemented.

Table 12. *Categories and rankings of estuaries according to land use and estuary condition*

Category	Estuary	Ranking
Highly modified	Mersey	5
	Don	5
	Leven	5
	Emu	5
	Cam	5
	Inglis	5
	Duck	5
Moderate change	Port Sorell	3
	Blythe	3
	Montagu	3
Comparatively unmodified	Forth	1
	Black	1
	Detention	1
	Welcome	1
	Arthur	1
	Pieman	1

Criterion 4 – Groups reliant on estuaries (e.g. marine farmers / industry / tourism)

There are a number of groups in the Cradle Coast Region that are reliant on the health of estuaries economically and socially. Marine farms producing shellfish are directly dependent on high levels of water quality. Some wild fisheries also rely on the health of estuaries, with many fish, including whitebait and flounder, completing part or all of their life-cycle in or around estuaries.

Less distinct are the requirements of the tourism industry for healthy estuaries. Tourism is a growing industry throughout Tasmania, with the Cradle Coast being no exception. There are many tourist activities focused around estuaries that are both directly and indirectly related to water quality. Recreational activities such as fishing, boating, swimming and diving all have the potential to draw people into the Region, particularly "untouched" and rugged areas such as the west coast. These activities also contribute to the lifestyle values held by locals in the Region, and require a certain level of water quality to maintain them into the future.

The Montagu, Duck and Port Sorell all have marine farms active in the estuaries. As the shellfish industry is directly reliant on high levels of water quality to maintain a high level of product, these estuaries all ranked highly for this criteria. *Ranking 5*

The Arthur and Pieman estuaries provide magnificent natural scenery for tourists and support boat cruises. There is also potential for other tourist ventures to develop such as bird, whale and seal watching tours (CCNRM, 2005). Recreational fishing also draws people from outside the Cradle Coast. *Ranking 4*

The Emu, Mersey, Leven and Inglis estuaries all provide a focus for major population centres in the Cradle Coast. A slide in the water quality of these estuaries would detract from the overall appeal of the towns. However, due to the fact that they are major population centres, estuarine water quality is potentially under pressure from urbanisation and the regular use of these waters as port facilities. *Ranking 3*

To some extent most other major estuaries in the Cradle Coast Region also have groups reliant upon continuing good water quality. In many instances there are shack sites, camping grounds or reserves (both recreation and conservation) around estuaries. Various local councils monitor for recreational water quality from or in the vicinity of the Forth, Don, Blythe, Cam, Black and Detention estuaries, indicating that people regularly use these waters for primary and secondary contact activities. *Ranking 2*

Welcome Inlet is perhaps the only estuary not significantly relied upon by any group in the Cradle Coast Region. It is isolated in the far north-west, with farmland and land of "minimal-use" occurring in patches surrounding the estuary. *Ranking 1*

Criterion 5 – Areas of international or special significance

This criterion refers to regions that have been declared significant by international, Commonwealth or State requirements. It includes estuaries and/or catchments that

fulfil Ramsar criteria, contain national parks or have significant state, conservation and cultural heritage sites in the Cradle Coast Region.

The Robbins Passage wetlands area is a prominent site of outstanding significance in the Cradle Coast Region. This area is within the bounds of the Montagu estuary and is of international significance to shorebirds. It fulfils the ecological criteria to be listed as a Ramsar site and accordingly the Montagu estuary receives the highest ranking for this criterion. The Black River estuary has been declared as having critical conservation significance in a classification of Tasmanian estuaries and an assessment of their conservation significance (Edgar *et al.*, 1999). It is the only estuary in the Cradle Coast Region to have its conservation significance classified as critical. It was recommended that an estuarine marine protected area be created using legislation for the Black River estuary. *Ranking 5*

The Narawntapu National Park (formerly the Asbestos Range National Park) covers the eastern side of the Port Sorell estuary. The Narawntapu National Park has unique coastal healthlands, an amazing density of wildlife and is rich in Aboriginal and European heritage. The "Springlawn" area of the National Park, that borders Port Sorell, covers extensive saltmarsh and lagoon areas that support a rich concentration of birds. *Ranking 4*

The only Tasmanian Conservation Reserve in the Cradle Coast Region is the Arthur-Pieman Conservation Area. This reserve stretches along the west coast from the Arthur River estuary to the Pieman River estuary and includes transgressive dune systems rich in Aboriginal heritage. Within the catchments of the Arthur and the Pieman are other significant sites such as the Savage River National Park (Arthur and Pieman) and the Hellyer Gorge State Reserve (Arthur). *Ranking 3*

A State Reserve exists on the Mersey River estuary at Mersey Bluff, considered a significant Aboriginal cultural heritage area. The headwaters of the Mersey, Forth and Leven all originate in the Tasmanian Wilderness World Heritage Area as part of the Cradle Mountain Lake St Clair National Park or the Walls of Jerusalem National Park. Whilst the impact of this on the estuary is hard to define, the World Heritage Area represents an area of international significance within the catchments of these three estuaries. The other sites that deserve mention are the Welcome River Reserve and the Dismal Swamp Reserve in the Welcome catchment. The Welcome River Reserve, sited in the lower Welcome catchment, contains nationally significant, well preserved, swamp forest communities unique in Tasmania. *Ranking 1*

There are numerous other public reserves in the Cradle Coast Region, some bordering estuaries. Whilst all of these are special in their own right, they are not considered significant enough to be included in this criterion.

Criterion 6 – The presence of threatened species or sensitive habitats

This criterion focuses on ecological significance. Endangered species known to occur in estuaries and coastal waters in the Cradle Coast Region include the Australian grayling and the native screwshell, *Gazameda gunnii*, as well as several species of seabirds. Estuaries containing areas such as shark nurseries or tightly regulated recreational fisheries were also considered for this criterion.

Sensitive habitats in the Cradle Coast area include wetlands, saltmarsh and seagrass (CCNRM, 2005). Wetlands and saltmarsh in Tasmania have previously been impacted by human activities, such as drainage and land reclamation, and substantial areas of these habitats have been lost (SDAC, 1996). Seagrass beds are highly productive areas and provide nursery grounds for commercially important fish species (Edgar, 2001). However, seagrass is also sensitive to highly turbid and nutrient rich environments (Rees, 1993) and hence is likely to decline in impacted environments. The Montagu Estuary/Robbins Passage wetlands and salt marshes provide breeding, roosting and feeding habitat for the largest density and diversity of shorebirds found anywhere in Tasmania (CCNRM, 2005). This area is home to the endangered little tern and the vulnerable hooded plover. There are also relatively extensive salt marsh and seagrass beds in this area.

When surveyed for macroinvertebrates by Edgar *et al.* (1999) the Welcome Inlet of the far north-west had a higher species richness than any other estuary in the Cradle Coast Region. This estuary also contains large areas of salt marsh – one of the most threatened vegetation communities in Tasmania. *Ranking 5*

Port Sorell is the only officially declared Shark Refuge area in the Cradle Coast Region. Shark Refuges are areas critical to the breeding of school and gummy shark and no species of shark, including all rays and stingrays, can be taken from the estuary. There is a very diverse range of shore habitats and ecosystems found in the Port Sorell estuary, including sandy and rocky shores, mudflats, sandflats, reefs and saltmarshes (Bentley, 2002). Seagrass beds also used to flourish within Port Sorell, although have declined in recent times (Rees, 1993). There are several species of seabirds present, with islands in the estuary used as breeding grounds. One of the largest colonies of Little Penguins on mainland Tasmania is also present at Port

Sorell. These birds are highly sensitive to human disturbance and increasingly under threat in the Cradle Coast Region. *Ranking 5*

There are several other threatened species recorded in the Cradle Coast. The Australian Grayling, *Prototroctes maraena*, is listed as vulnerable, with several important locations in the Cradle Coast Region, including the Pieman, Arthur, Detention, Cam, Duck, Blythe, Inglis, Leven, Forth, Don and Mersey estuaries. Spawning of this species occurs in freshwater, although they undergo a marine larval phase – the newly hatched fry are presumably swept downstream to brackish water in an estuary or to the ocean where they remain for around six months before returning to freshwater (Berra, 1982). Thus obstructions to freshwater flow within catchments (e.g. dams) can impact on the reproduction of this species.

The endemic freshwater lobster is also found in the Cradle Coast region, with hotspots including lower sections of rivers that have intact riparian vegetation and low siltation. The best stretches of habitat include the lower reaches of the Black and the Detention, although the Arthur, Leven and Emu are also potential hotspots (T. Walsh, pers.comm., 2006) There is anecdotal evidence to suggest that lobsters do sometimes move below the tidal limits, with traditional sightings in the lower Duck and Inglis rivers (T. Walsh, pers. comm., 2006).

Threatened bird species include the azure kingfisher, listed as endangered. It favours estuaries with good overhanging vegetation and slower moving waters. It is known to occur around the Leven, Black, Arthur and Pieman estuaries (R. Gaffney, pers. comm.). White bellied sea-eagles, listed as vulnerable, also occur along the coastal strip in the north-west, but have also been recorded around the Arthur and Pieman estuaries on the west coast. Hotspots include Hunter Island in the far north-west, but also most major estuaries in the Region (B. Brown, pers. comm.). As a result of this spread of threatened species across the Cradle Coast, all remaining estuaries for this criterion received the same ranking. *Ranking 2*

Outcomes of estuary ranking by criteria

Rankings for each criterion were summed to provide an overall ranking for each estuary (Table 13). This is a simple method of trying to prioritise estuaries according to their value for monitoring. Other methods of ranking can be tried if the priority list does not meet with stakeholder approval. The Port Sorell and Montagu/Robbins Passage estuaries have been highlighted by this ranking system as having very high importance for monitoring. Both of these estuaries received the highest possible ranking in four out of the six criteria.

Table 13. *Outcome of estuary ranking by criteria (ranked from highest to lowest) with key estuaries shaded*

	1. Biophysical	**2.** Monitoring	**3.** Activity	**4.** Reliance	**5.** Special Significance	**6.** Threatened species/ habitat	**TOTAL**
Port Sorell	5	5	3	5	4	5	27
Montagu/ Robbins Passage	3	5	3	5	5	5	26
Duck	5	5	5	5	0	2	22
Black	5	5	1	2	5	2	20
Leven	5	3	5	3	1	2	19
Arthur	5	4	1	4	3	2	19
Inglis	5	2	5	3	0	2	17
Cam	5	2	5	2	0	2	16
Mersey	1	3	5	3	1	2	15
Don	3	1	5	2	0	2	13
Blythe	5	1	3	2	0	2	13
Emu	1	2	5	3	0	2	13
Detention	3	4	1	2	0	2	12
Welcome	3	1	1	1	1	5	12
Pieman	1	1	1	4	3	2	12
Forth	1	1	1	2	1	2	8

The ranking system also indicates that the Duck and Black estuaries are considered high priority for monitoring. Both received high rankings in three or more criteria and overall rated highly compared to other estuaries in the Cradle Coast Region.

The Leven, Inglis, and Arthur estuaries also all received high overall rankings. These estuaries are also important to provide a wider geographical distribution of monitoring sites across the Cradle Coast region.

Key coastal areas

In comparison to estuaries, coastal waters are much harder to categorise and rank according to criteria. Coastal waters are generally not discrete systems – the boundaries between one section of coastline and the next are often blurred, with impacts and issues being of a similar hazy nature.

Sharples (1998) very broadly divided the Cradle Coast region into three sections:-

- The highly exposed and high energy west coast, predominantly rocky but with a extensive sandy beaches and inland sand sheets. Very little human coastal development;
- A sheltered region between Woolnorth Point and Circular Head, with extensive low-lying coastal plains (used in agriculture) and prograding sandy shorelines and intertidal flats; and
- A moderately exposed, mainly rocky coast from Circular Head eastwards with some sandy beaches. One of the most intensively developed coastlines in Tasmania, with considerable alteration of coastal landforms.

Of these three sections of coastline, the West Coast of Tasmania regularly experiences rough seas and is largely considered to be unsuitable for monitoring. The second section, being the sheltered region between Woolnorth Point and Circular Head, includes Robbins Passage. In an earlier section of this report, the Robbins Passage area was recommended for monitoring as part of the Montagu River estuary, as it is a body of water with both estuarine and coastal influences. There are several programs that have been conducted and/or are ongoing in this region of coastline. Through the Seamap Tasmania program, TAFI have mapped the deeper channel and the seagrass beds in Robbins Passage. TSQAP and the shellfish farmers also have five automatic receivers in the Robbins Passage/Big Bay area, continuously collecting data for temperature and salinity. Therefore an extension of any monitoring conducted in the Montagu River estuary into Robbins Passage/Big Bay would be the logical site for monitoring of coastal waters in the Woolnorth Point to Circular Head area. Potential monitoring sites within the third distinct section of coastline identified by Sharples (1998) – the area of coast stretching from Circular Head to Port Sorell – will be discussed in the remainder of this section.

There have been several monitoring programs conducted in the section of coast from Circular Head to Port Sorell, with many of these ongoing. TAFI is currently running two NRM funded programs: the Seamap Tasmania project, mapping benthic habitat in the north-west coast and the Rocky Reef project, examining plant, invertebrate and fish biodiversity on a number of sites, including Circular Head, Rocky Cape, Sisters

Beach, Boat Harbour, and the coast off Ulverstone and Devonport. The Waratah-Wynyard Council also samples Sisters Beach and Boat Harbour sewage outfall sites. This monitoring is reasonably comprehensive, as stipulated by licensing requirements from the State government. There has also been a large amount of sampling conducted in the coastal waters off Burnie. Historically, this stretch of coastline has been the discharge point for three large industries: an acid plant (closed 1975), a paper mill (Australian Paper) and a paint pigment factory (Tioxide – closed 1996). Both Tioxide and Australian Paper have run extensive monitoring programs around outfalls to assess the effect on biota. The Tioxide monitoring program has ended, but Australian Paper still sample in Emu Bay. Through their recreational water quality testing, Burnie City Council also monitor these waters for faecal coliform, with seven sites covering an areas from Cooee Beach to Wivenhoe Beach in Emu Bay. Further to this, in 2002, Burnie City Council released a report on stormwater management, collecting water quality data and identifying pollution issues and impacts in the Burnie stormwater system (Sharman, 2002). Major ports along the north-west coast have had baseline assessments conducted for invasive species, which are often associated with increased boat traffic. These ports include Devonport, Burnie, Stanley and Port Latta. Devonport City Council also monitors sites in coastal waters around Devonport as part of their recreational water quality monitoring. The possibility of linking coastal waters monitoring with any of the abovementioned environmental sampling programs is a suggestion that needs to be examined further when selecting coastal sites for ongoing monitoring.

There are several groups reliant on these waters, with a number of commercially and recreationally important marine taxa occurring in the Region. The southern rock lobster, blacklip and greenlip abalone, the pale octopus and various benthic and pelagic fish all occur on this stretch of coastline. Locals and tourists alike use these waters to engage in primary and secondary contact activities such as swimming, diving, snorkelling, recreational fishing and boating. Tourism in particular is a major drawcard for this region of coastline, featuring attractions such as the Nut, Rocky Cape National Park, Table Cape, as well as many holiday shack settlements such as Sisters Beach, Boat Harbour and Turners Beach.

In terms of areas of special significance, there are currently no marine protected areas (MPAs) of any kind within this region of coastline. However, as part of developing a representative MPA system within Australia, candidates from around the state were identified. A potential candidate MPA region between Circular Head and Port Sorell includes the stretch of coastline from Rocky Cape to Boat Harbour. This strip of coast contains a complex reef system with an associated diversity of macroalgal, invertebrate and fish species (Barrett and Wilcox, 2001). Rocky Cape National Park

provides another area of significance in the Region.

Sensitive habitats include extensive seagrass beds along north-western Tasmania, particularly the area between Rocky Cape and Table Cape. Threatened species include the native screwshell, *Gazameda gunnii*, which is listed as vulnerable on the threatened species list and is known to occur in this coastal area, along with the whitebellied sea eagle.

The logistics involved in the monitoring of coastal waters are very important. Unlike estuaries, coastal waters are generally not protected, sheltered environments. Consequently, in terms of a long term monitoring program, there is a question over who can regularly take samples. Commercial fishers, tourist operators, Fishcare volunteers and any others who regularly use the shipping area could be potentially important groups in maintaining a long term monitoring program. However, the overall ability to integrate these groups with already existing sampling programs should be a priority in selecting which coastal waters to monitor. Areas such as the coastal waters off Burnie or the coastline from Sisters Beach to Boat Harbour, which have a considerable number of programs established that appear to be highly feasible for further monitoring.

Logistics of monitoring key estuaries and coastal waters

The logistics of establishing a monitoring program include where, when and how often to sample, who can collect samples and take measurements, and where funding for monitoring comes from after the NRM/NHT project is finished.

This project aims to establish an integrated water quality monitoring framework that will be sustainable in the long term. For this to occur, key partnerships need to be formed in a way that benefits all groups involved. This will require commitment and support from state and local government, NRM regional bodies, community groups and local industries. If these groups can work together, each providing input to the process, then a cost-effective and valuable monitoring program of the condition of estuaries on the northwest coast can be established.

This will involve developing a monitoring program which incorporates where possible existing baseline data and environmental data currently being collected, e.g. TSQAP shellfish waters monitoring and recreational water quality data being collected by councils. Councils, local industries and community groups will be encouraged to conduct any monitoring that they are involved with in association with the monitoring framework being developed in this project. Missing baseline data will be collected where possible, hopefully with NRM Cradle Coast support. If local stakeholders can work together to establish the monitoring program, then the ongoing financial support from NRM and State Government is more likely to occur.

In the longer term it is envisaged that estuary monitoring will be linked with monitoring freshwater upstream to provide a whole of catchment approach to monitoring and management.

Once the estuaries and coastal waters to be monitored have been agreed on, detailed sampling programs will be determined. This will involve selecting sample sites, based on the size and geomorphology of the estuary, ease of access, and requirements of local stakeholders. The environmental variables to be monitored will be based on the NRM Estuarine, Coastal and Marine Indicator list developed as part of the Tasmanian Indicator Compendium, which is a subset of the National list of coastal, estuarine and marine indicators. Although the indicators to be monitored in Tasmania have been agreed on, the details are still in draft form (available at http://www.dpiw.tas.gov.au/inter.nsf/ThemeNodes/CDAT-593VMB?open). The methods for monitoring each indicator will be based on a report currently being prepared by Christine Crawford at TAFI which provides information on monitoring each indicator in Tasmania.

Although the details of where the monitoring data will be housed and who will be the custodian of the data are yet to be sorted, it is anticipated that the data will be freely available to use by local councils, state government, community groups and any other stakeholders involved. These data are for the benefit of the people of the Cradle Coast Region, to help them make more informed management decisions, as well as promote the Region as active in natural resource management.

Future directions

The next steps in the development of a coordinated monitoring program for estuaries and coastal waters are:-

- Collate feedback and hold a workshop to gather opinions and thoughts of stakeholders in the Region. This includes local councils, Waterwatch and community groups and state government (DPIW, DTAE). The aim of this process will be to:-
    a) determine key estuaries and coastal waters through a discussion process involving as many people as possible; and
    b) make a decision on how to co-ordinate the monitoring program and make data easily accessible to all groups involved.
- Assess practicalities of running monitoring programs in key estuaries and coastal waters. This includes the selection of sampling sites within estuaries, how often to monitor and what samples to collect.
- Begin monitoring.
- Establish a database for results so that all stakeholders have access to information.
- Establish baselines for key estuaries and coastal waters using data collected by the monitoring program, as well as already existing data.
- Develop a report card format for reporting on the condition of estuaries being monitored.
- Final report outlining baseline assessments, the monitoring framework and potential water quality objectives and targets.

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